GUIDED SEARCH OF VOLCANIC GLASSES IN CONTINUOUS THIN SECTIONS OF 73002.

C. J.-K. Yen[1,2], B. L. Jolliff[1,2], P. K. Carpenter[1,2], A. Minocha[2,3], R. C. Ogliore[2,3], J. J. Kent[4], R. A. Zeigler[5], J. Gross[5,6,7,8], C. K. Shearer[8,9], and The ANGSA Science Team[10]. [1]Dept. of Earth and Planetary Sciences, Washington University, St. Louis, MO 63130 (yenc@wustl.edu); [2]McDonnell Center for the Space Sciences, Washington University, St. Louis, MO 63130, [3]Dept. of Physics, Washington University, St. Louis, MO 63130, [4]GeoControl Systems, Jacobs JETS Contract, Houston, TX 77058; [5]NASA Johnson Space Center (JSC), Houston, TX 77058; [6]Dept. of Earth & Planetary Sciences, Rutgers University, Piscataway, NJ, 08854; [7]Dept. of Earth & Planetary Sciences, American Museum of Natural History, New York, NY 10024; [8]Lunar and Planetary Institute, Houston TX 77058; [9]Dept. of Earth and Planetary Science, Institute of Meteoritics, University of New Mexico, Albuquerque, New Mexico 87131; [10]includes all members of the ANGSA Science Team, which includes members of JSC curation.

Introduction: Continuous thin sections of the upper portion (73002) of the double drive tube 73001/73002 were made for the ANGSA initiative. These thin sections are essentially epoxy grain mounts of lunar soil with preserved stratigraphy and are samples 73002,6015/6016/6017/6018, numbered from shallowest to deepest. Carpenter et al. [this meeting] created quantitative electron probe microanalysis (EPMA) maps of these four thin sections, and Minocha et al. [this meeting] coregistered the image data with optical microscope images for ease-of-analysis in a webtool. We used these data to filter and identify volcanic picritic glasses in whole thin sections, with the preliminary results from ,6016 presented in this abstract.

Volcanic picritic glasses are crucial to our understanding of the thermochemical evolution of the Moon as they represent our best proxy for the composition of the lunar mantle [3,4]. The linkage between volcanic glasses and mare basalts, even when both are found at the same sampling location, remain unclear except for one possible parent-daughter relationship between Apollo 17 VLT basalts and Apollo 17 green glass [5,6]. We demonstrate how a simple yet effective guided search for volcanic glass can be conducted in a complex sample by using datasets to distinguish targets from impact glass and other phases.

Methods: The data used in this guided search within ,6016 were a high-resolution backscattered-electron (BSE) image, quantitative EPMA maps, a plane-polarized optical microscope image, and a cross-polarized optical microscope image. The BSE image has a resolution of 1.5 μm per pixel, and the quantitative EPMA images were acquired at 9-10 μm per pixel resolution for ten elements: Si, Ti, Al, Cr, Fe, Mn, Mg, Ca, Na, and K [1]. The optical microscope images were warped to be coregistered with the quantitative EPMA images [2]. We studied these data in the software ENVI.

To narrow down candidate regions of interest of potential volcanic glass, we created an image of Mg/Al using the quantitative EPMA data and set the filter to be 1.5-4.5 (Fig.1), according to previous studies of pristine lunar glasses and chemical distinctions from impact glass [3,7]. Regions that were highlighted and ~5×5 pixels (50 μm) or larger were then examined in the BSE and optical microscope images. The BSE and plane-polarized images were used to check for homogeneity and absence of schlieren and inclusions, though some leniency was applied because high-Ti glasses often have crystallized ilmenite. The cross-polarized image was used to check that the target was opaque and likely a glass. We then output the corresponding statistics from the quantitative EPMA data for each candidate volcanic glass region of interest (ROI) for further analyses.

Results and Discussion: 109 volcanic glasses were identified in ,6016 with average compositional totals between 98 and 102 wt.%. Of those, three were green/VLT glasses while the rest were orange/high-Ti glasses (Fig. 2). The most common false positive highlighted by the Mg/Al filtering was a titanian augite phase, which appears pinkish in plane-polarized light and shows birefringence (not opaque) in cross-polarized light, and thus easily excluded as not volcanic glass.

The 109 compositions are consistent with previous work showing distinct differences from those of mare soils and impact glass (Fig. 2) [3,7]. The Mg/Al values of the identified volcanic glasses ranged from 1.7 to 3.2, with TiO_2 contents ranging from 0.5 to 11.5 wt. %. A relatively large fragment (~0.4×0.5 mm) of what appears to be an ilmenite vitrophyre was identified by the search, with a composition similar to Apollo 17 orange glass (Fig. 3). An obvious outlier was a small VLT spherule (~50×50 μm) with an extremely high Mg # of 0.85, though it appears to lie on compositional array II of [7]. Its composition is unusually high in CaO and low in FeO, forming an olivine-plagioclase trend toward 76535 and 76335, perhaps suggesting some relationship with the Mg-suite. CIPW norm of this composition shows it is almost entirely olivine and plagioclase, like a troctolite. This spherule is similar in size and composition to ultra Mg # glass beads in Apollo 16 regolith breccias studied by [8] and [9] and is likely an unusual impact glass. This next-generational approach of synthesized datasets can be an important preliminary examination tool for Artemis sample return.

Acknowledgments: We thank the Preliminary Examination Team and the Curation Team at JSC for their outstanding work, and NASA for supporting the ANGSA program.

References: [1] Carpenter, P. K. et al. (2022) *A17-ANGSA Workshop*. [2] Minocha A. et al. (2022) *A17-ANGSA Workshop*. [3] Delano, J. (1986) JGR, 91, 201-213. [4] Shearer, C. and Papike, J. (1993) GCA, 57, 4785-4812. [5] Longhi, J. (1987) JGR, 92, E349-E360. [6] Longhi, J. (1991) GCA, 56, 2235-2251. [7] Delano, J. and Livi, K. (1981) GCA, 45, 2137-2149. [8] Wentworth, S. and McKay, D. (1988) LPSC 18. [9] Shearer, C. et al. (1990) GCA, 54, 1851-1857.

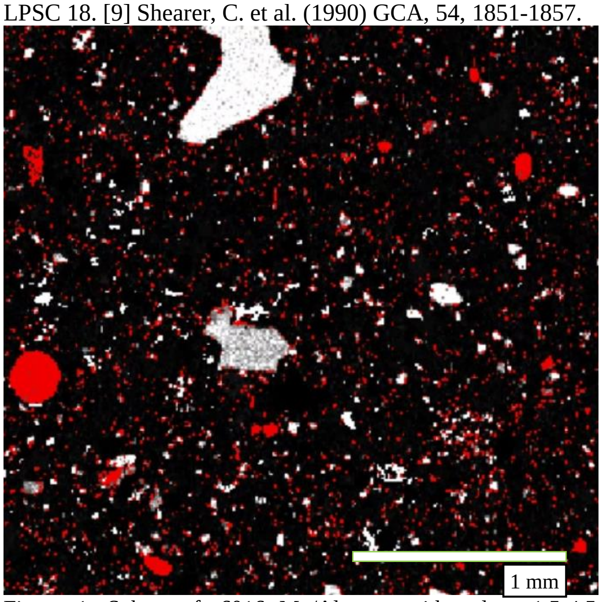
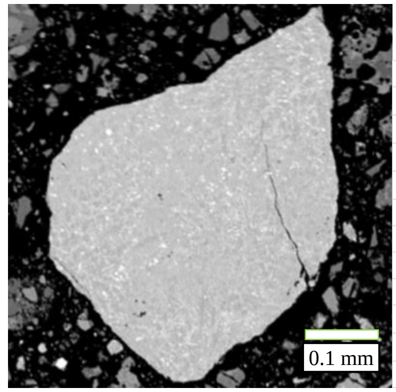
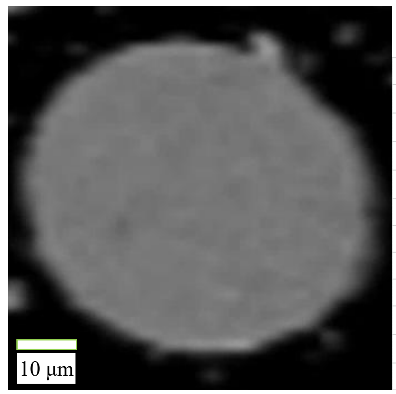


Figure 1. Subset of ,6016 Mg/Al map with values 1.5-4.5 highlighted in red.



Pixels n	859
SiO_2	38.31
TiO_2	11.59
Al_2O_3	7.62
Cr_2O_3	0.47
FeO	20.82
MnO	0.31
MgO	11.55
CaO	9.41
Na_2O	0.40
K_2O	0.06
Total	100.74

Figure 3. BSE image of the ilmenite vitrophyre (~0.4×0.5 mm) and its composition.



Pixels n	14
SiO_2	41.28
TiO_2	0.52
Al_2O_3	14.91
Cr_2O_3	0.12
FeO	7.75
MnO	0.24
MgO	24.38
CaO	8.95
Na_2O	0.07
K_2O	0.07
Total	98.15

Figure 4. BSE image of the unusual VLT glass (~50×50 µm) and its composition.

Figure 2. Discrimination diagrams of the 109 identified volcanic glasses, with blue annotations from [7].